SuperNOvA

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October 2, 2004

Assumptions

- Totally active detector (TASD)
- Detection of Supernova signals will require high live time front-end and DAQ
  - Online sparsification and Offline trigger
  - Won't be a free upgrade
- Possible in principle
  - Harvard prototyping a test system.
- Further challenges to come:
  - Backgrounds
  - DAQ rates

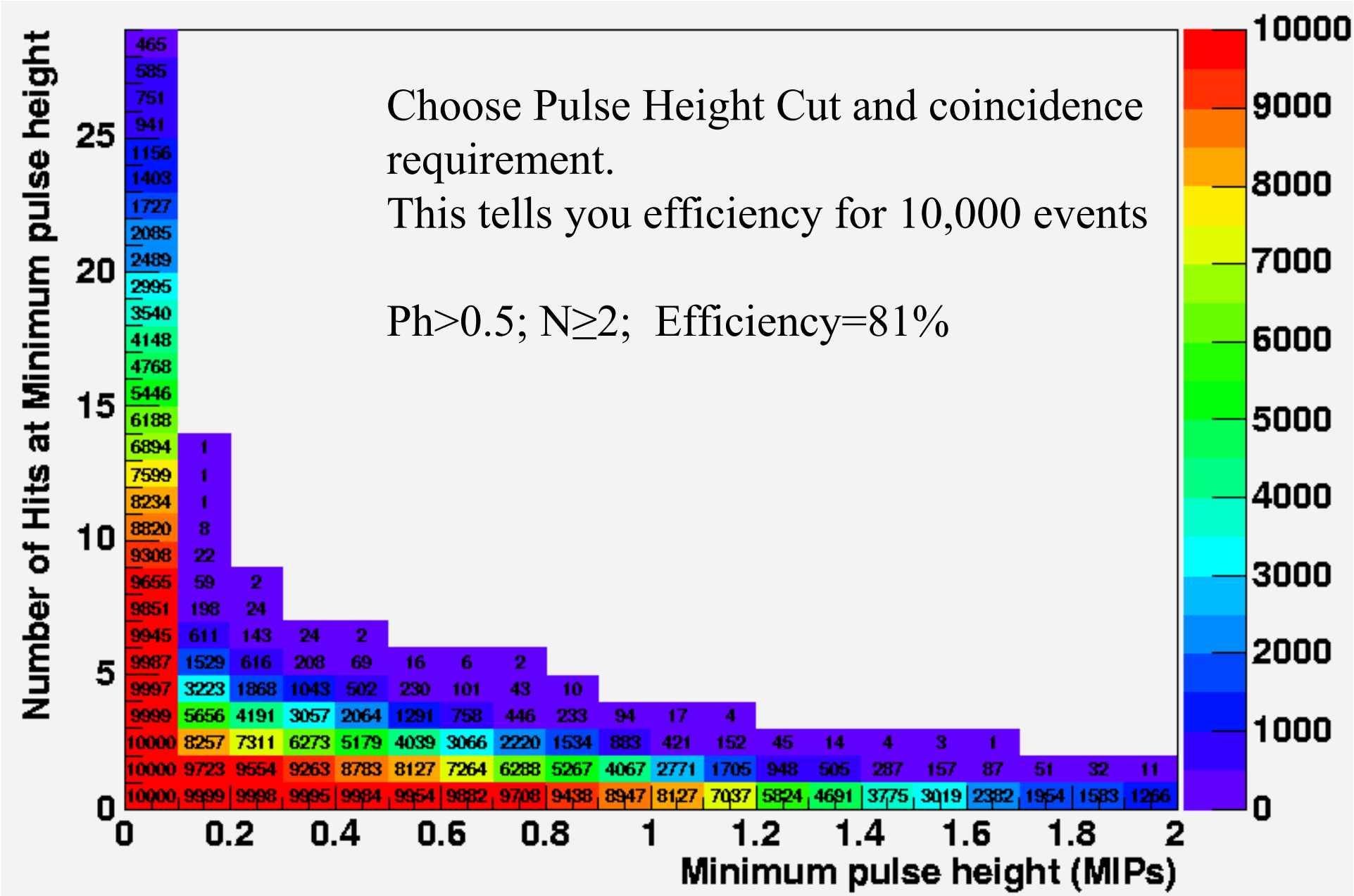
SuperNOνA Signals

- Primary Signal from $\bar{\nu}_e + p \rightarrow e^+ + n$
- Total signal –scaled from MiniBooNE
  - 8000 total interactions over ~10s;
  - 4000 in first second
  - Energy peaks at 20MeV, falling to about 60MeV
    - Positron dumps this energy locally, a few hits.

SN Backgrounds

• Natural radioactivity	Small
• Cosmic Ray Muons	500kHz
• EM from CR EAS	300kHz
• Neutrons	30kHz
• Total	~MHz

SN signal Pulse Height Frequency



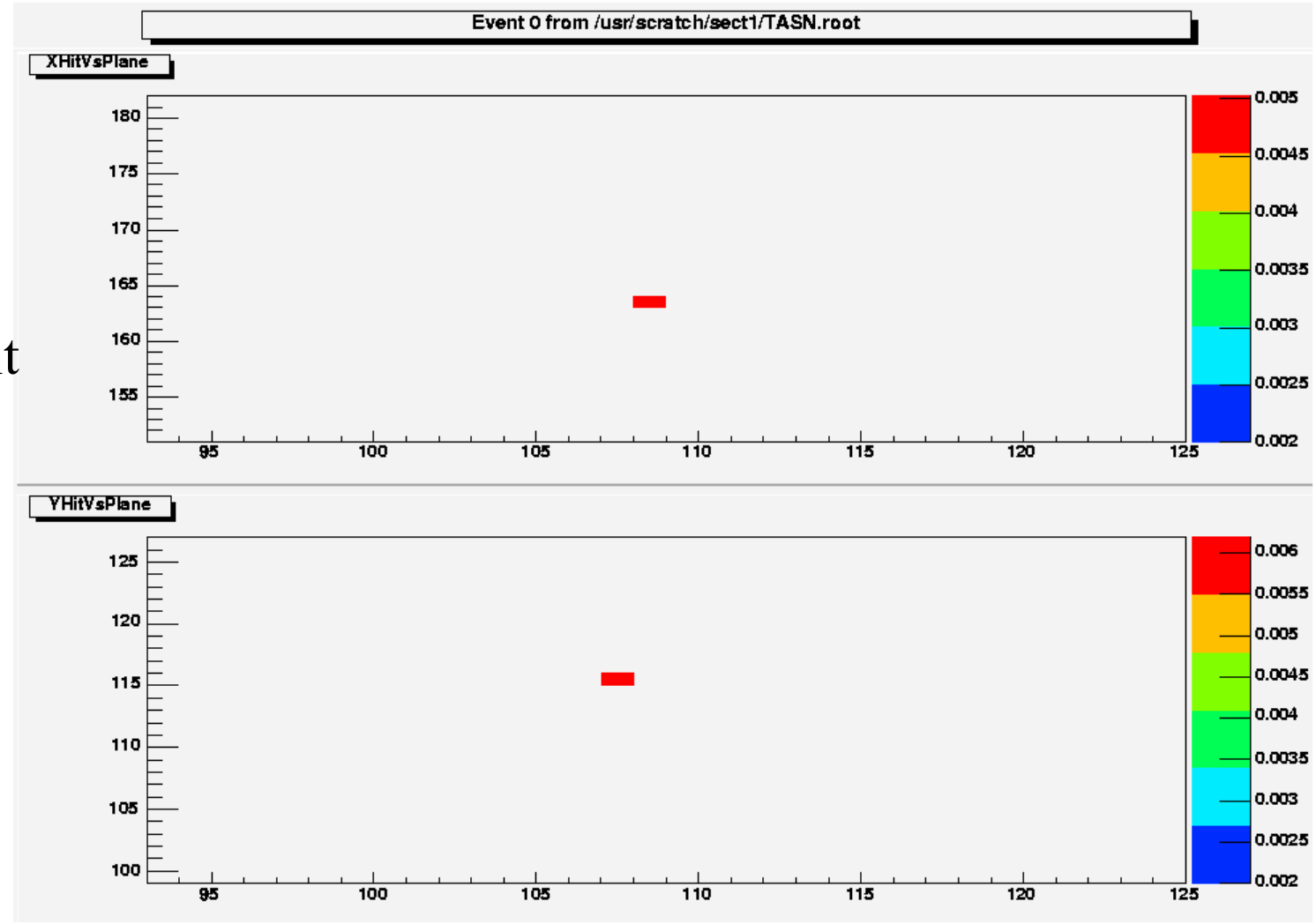
Signal With Reality

- Out of 8000, concentrate on 4000 from first 1 second, best possible S/N
- 80% trigger efficiency
  - 3200 events in 1 second
- 50% reconstruction efficiency
  - 1600 events in 1 second

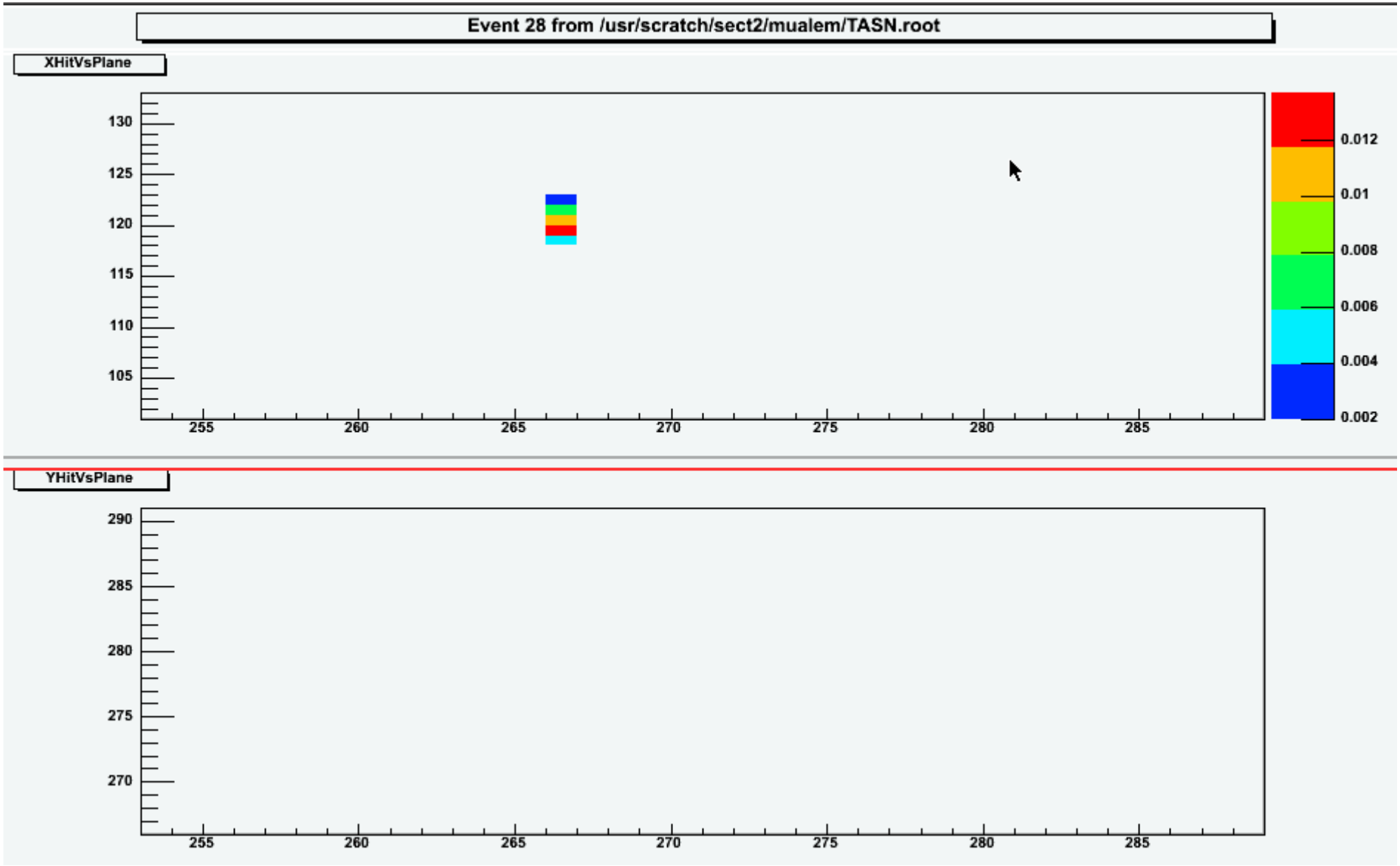
SN event passes trigger; accepted

16MeV e+

One ~1MIP hit in each view



SN event passes trigger, gets cut anyway



Natural Radioactivity

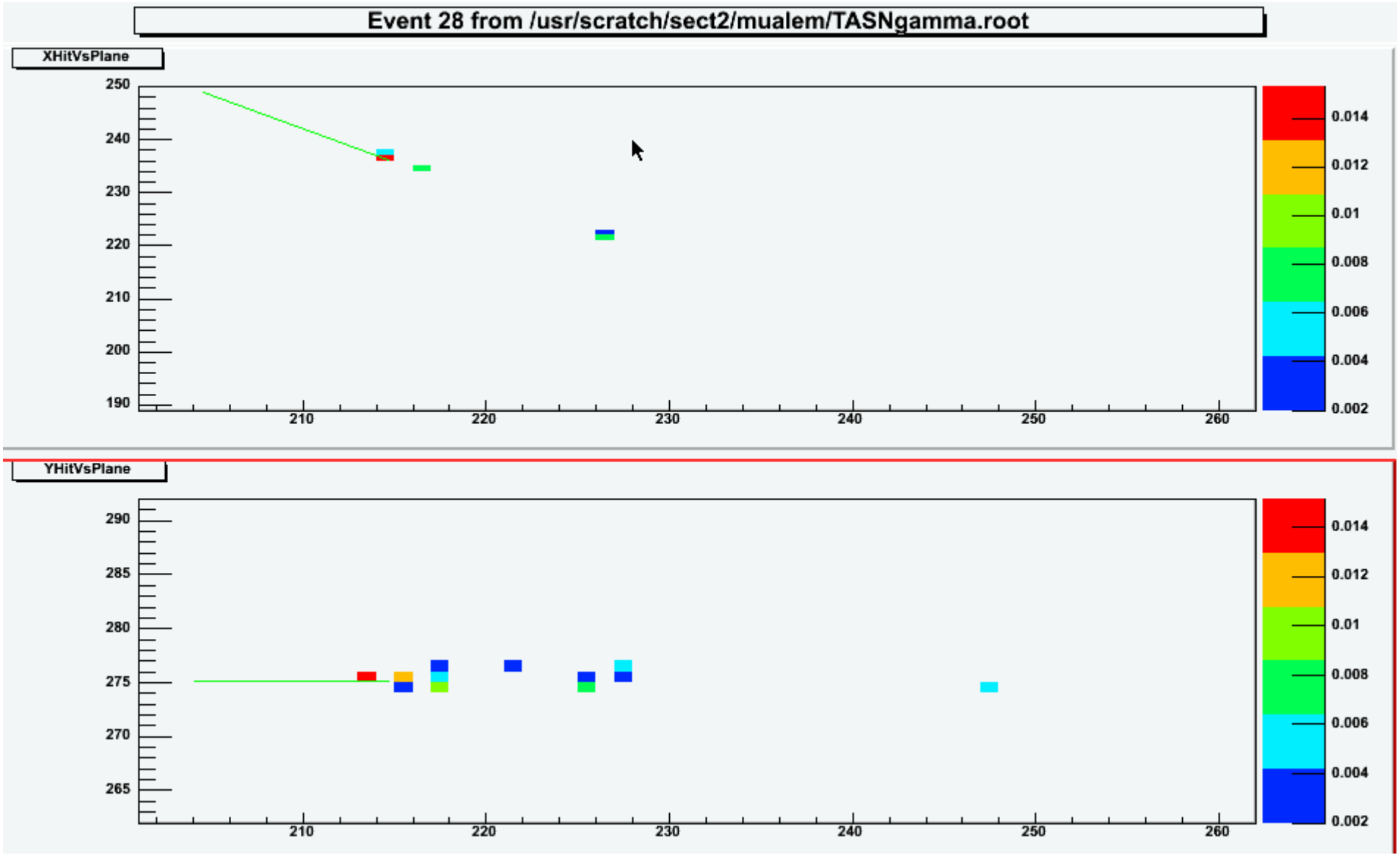
- Maximum energies around 2MeV, typical energies MUCH lower. Sparsification will get rid of vast majority of them.
- Setting threshold to coincident neighbors planes of ½ far-end is equivalent to a threshold of 2MeV, strongly suppressing background at (offline) trigger level.
- Requiring reconstructed (atten corrected) energy of 8MeV effectively eliminates this background.
- Most betas too low in energy, and most gammas Compton scatter giving small fractions of their energy; these get sparsified away.
- Unclear what it will be precisely, K-40 from concrete,U,Th…
- MINOS NOT a good guide,
  - sensitive to 1/3pe ~60keV –NOvA sensitive to 2MeV
  - Only bottom of detector near concrete…

EM background

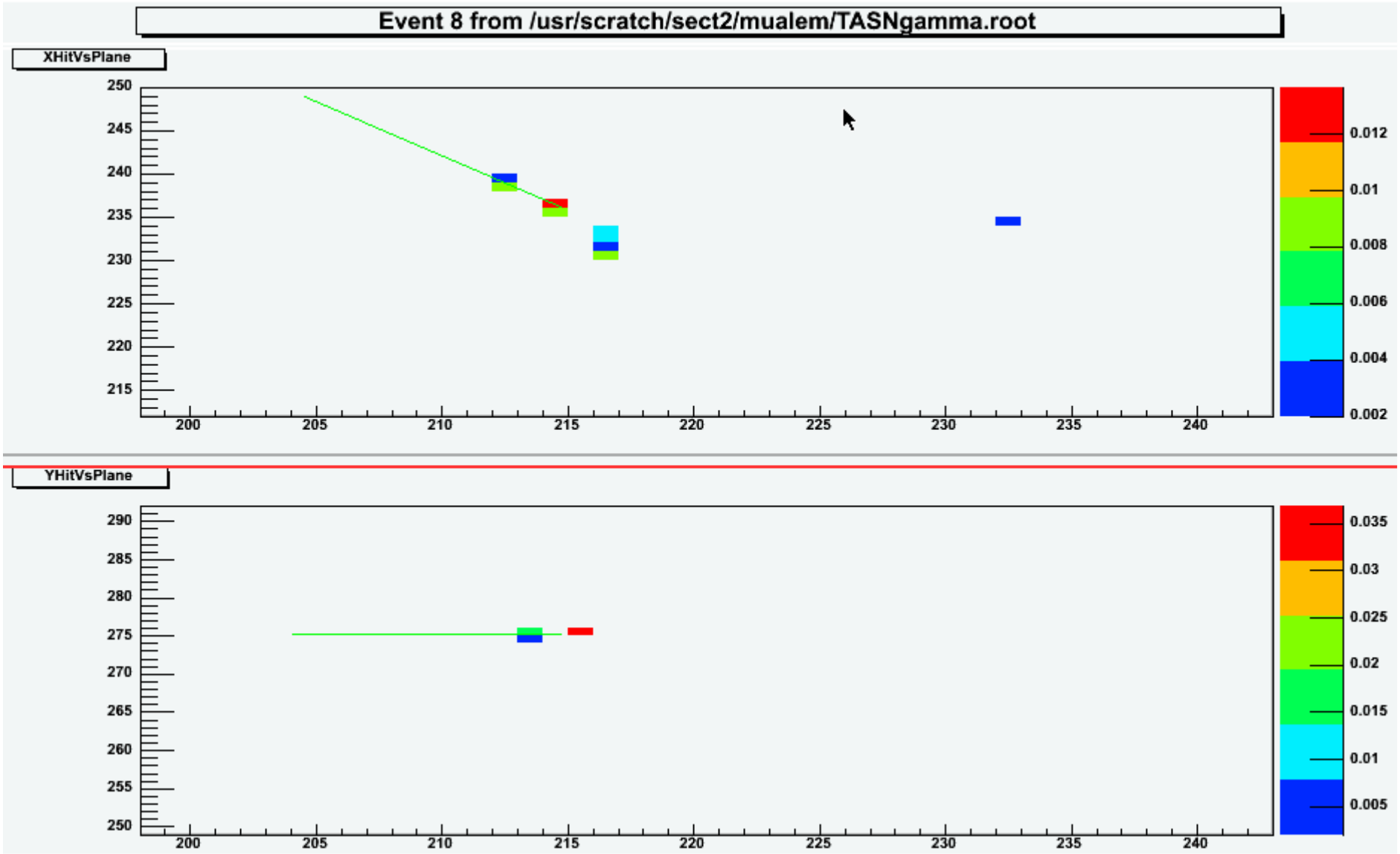
- Gammas and electrons from EAS
- Rate at surface 300kHz E>10MeV
  - 150kHz E>100MeV

CR gamma background

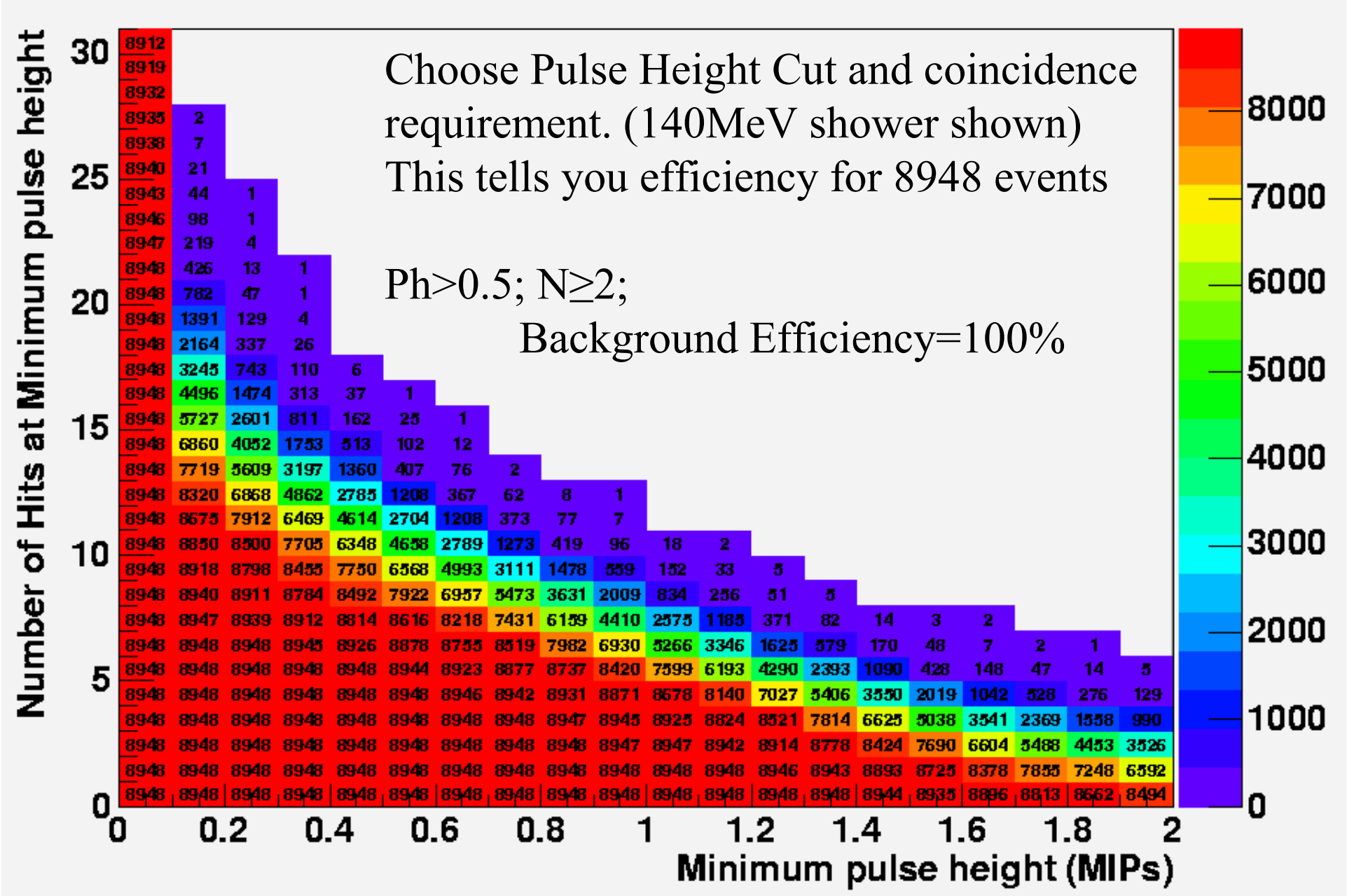
- Many vetoed, others eliminated by Etot



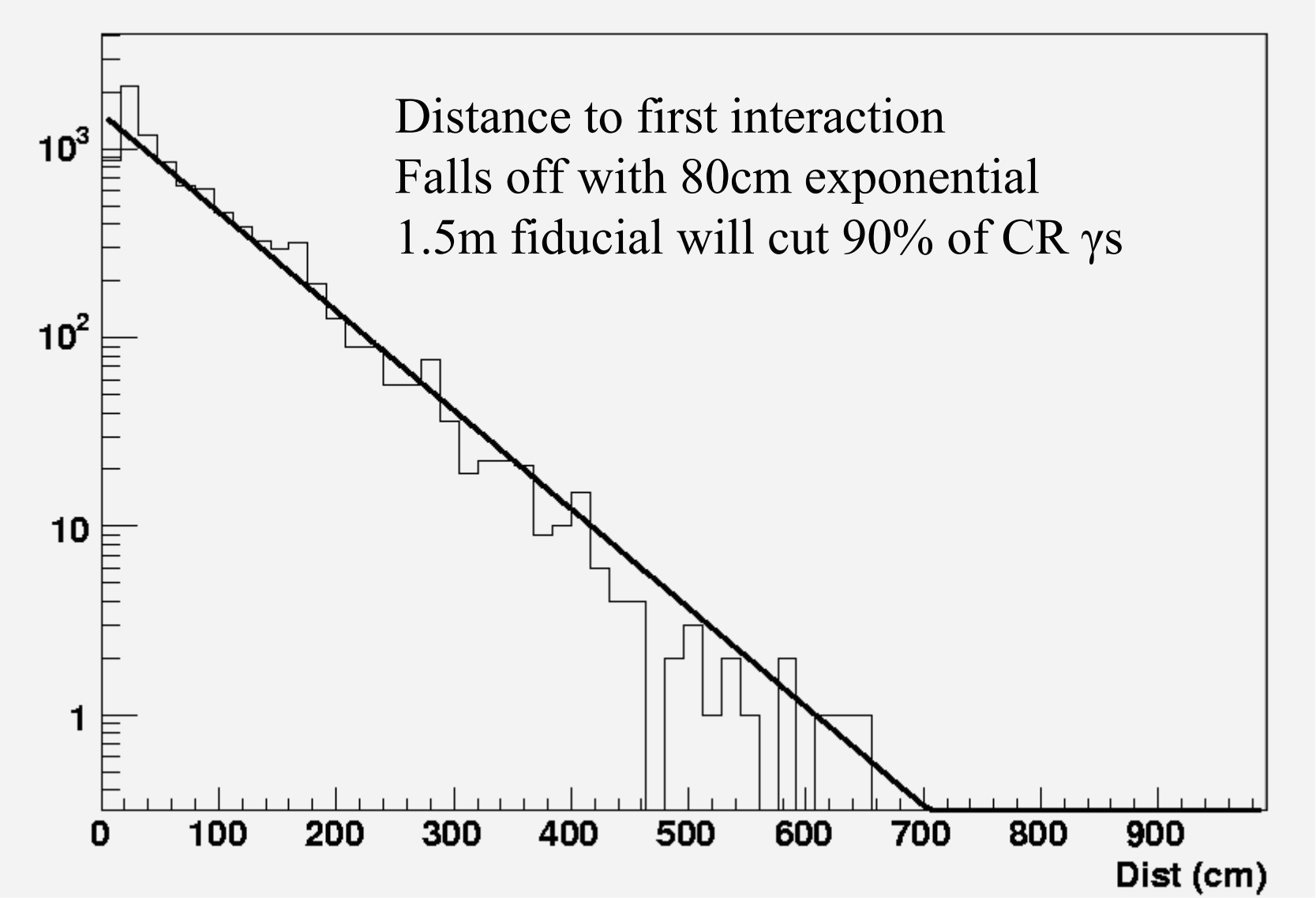
CR gamma Background



CR gamma signals Pulse Height Frequency



Gamma Attenuation



EM Background

- Use Veto region (1.5m)
  - Vetoes 90% of gammas and 100% of e+e
    - #photons/(#e^++ #e^-) = ~2
  - Reduces rate from 300kHz to 20kHz
    - Calorimetry reduces rate ~2x (EAS EM higher energy)
    - Not all independent (EAS) should reduce rate further 2? 10x? Corsika could help here.
    - Local (spatially) veto, so still ~90% live mass

Muon Background

- Muon rate in TA detector 500kHz.
- Median energy 4GeV
- About ½ will stop –many Michel electrons
  - Veto for 15μs at the end of the track
  - Negligible dead time

Muon Background

- Detector, and any reasonable veto region extremely efficient at detecting muons
- Assume if all data read out muon background (and Michel decays) ==0
- Main problem is horrendous data rate
  - 500kHz muons
  - Generates 300MHz of hits
  - ~3GB/s of data

Muon Veto

An idea:

Use coincidences in outer modules to veto muons.

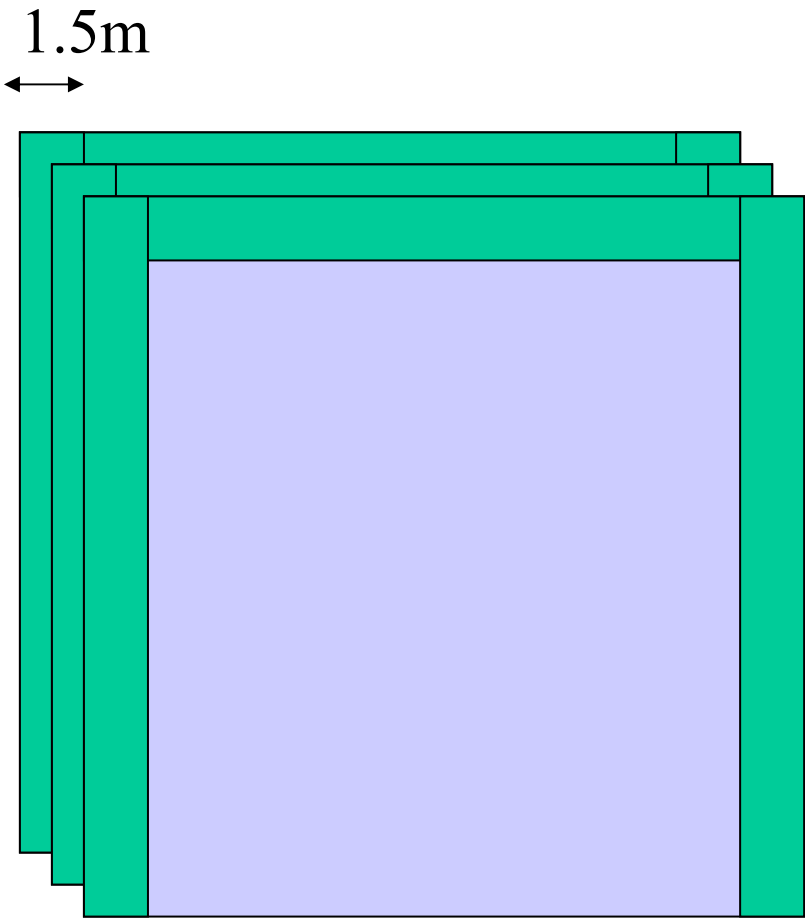
Hardware veto bit sent to a section of the detector, 1/10?

~T/2W=5/130=4% inefficiency 5cm gap=T,W is thickness of veto layer Data Rate ->100MB/s

Pipelined and sparsified data from front-end boxes allows decision to only send data for time segments without a veto hit

Possible problem from Michel electrons

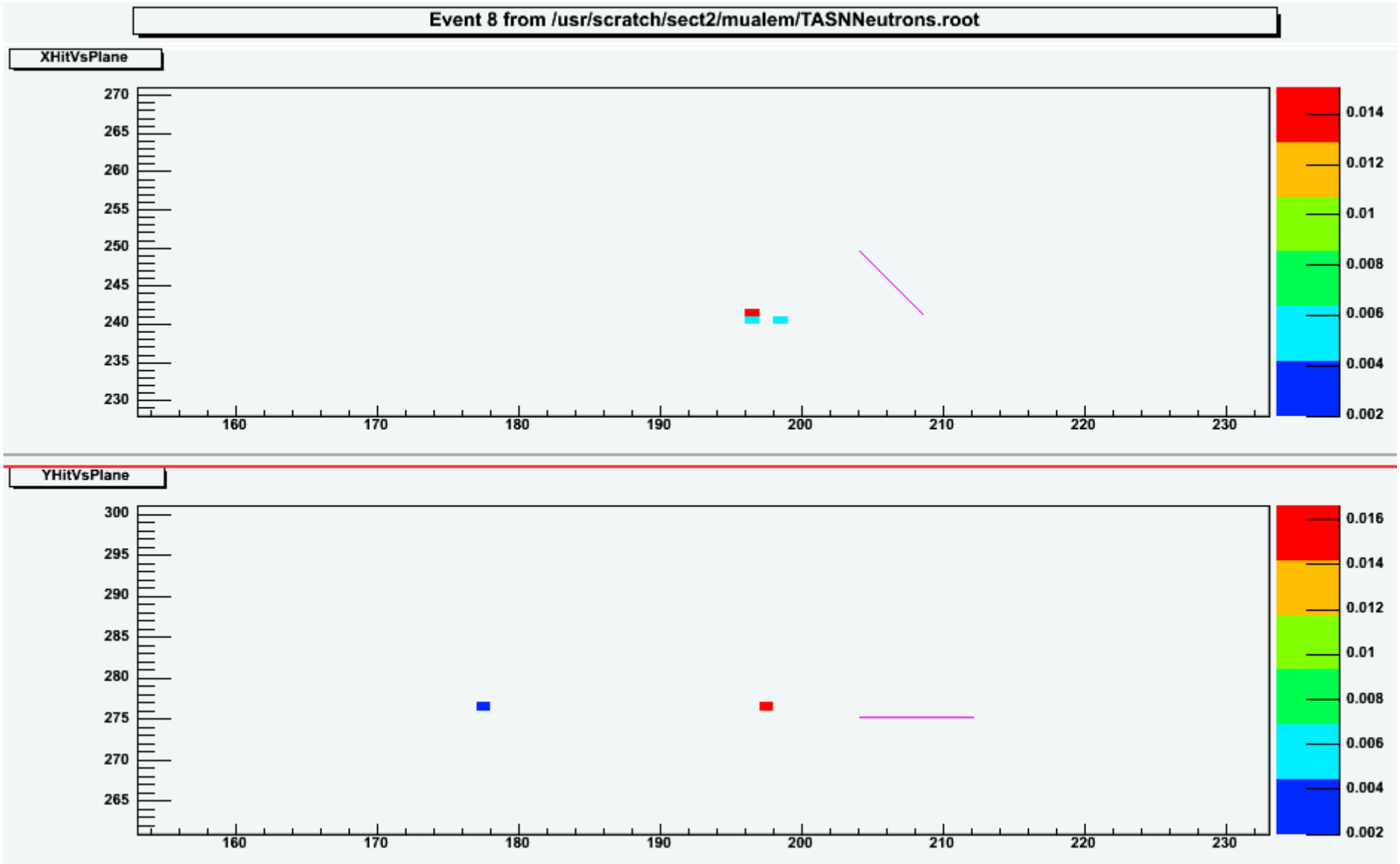
Probably need to veto a couple μs, reduces live fraction by .1*2μs*/2μs, a 10% hit



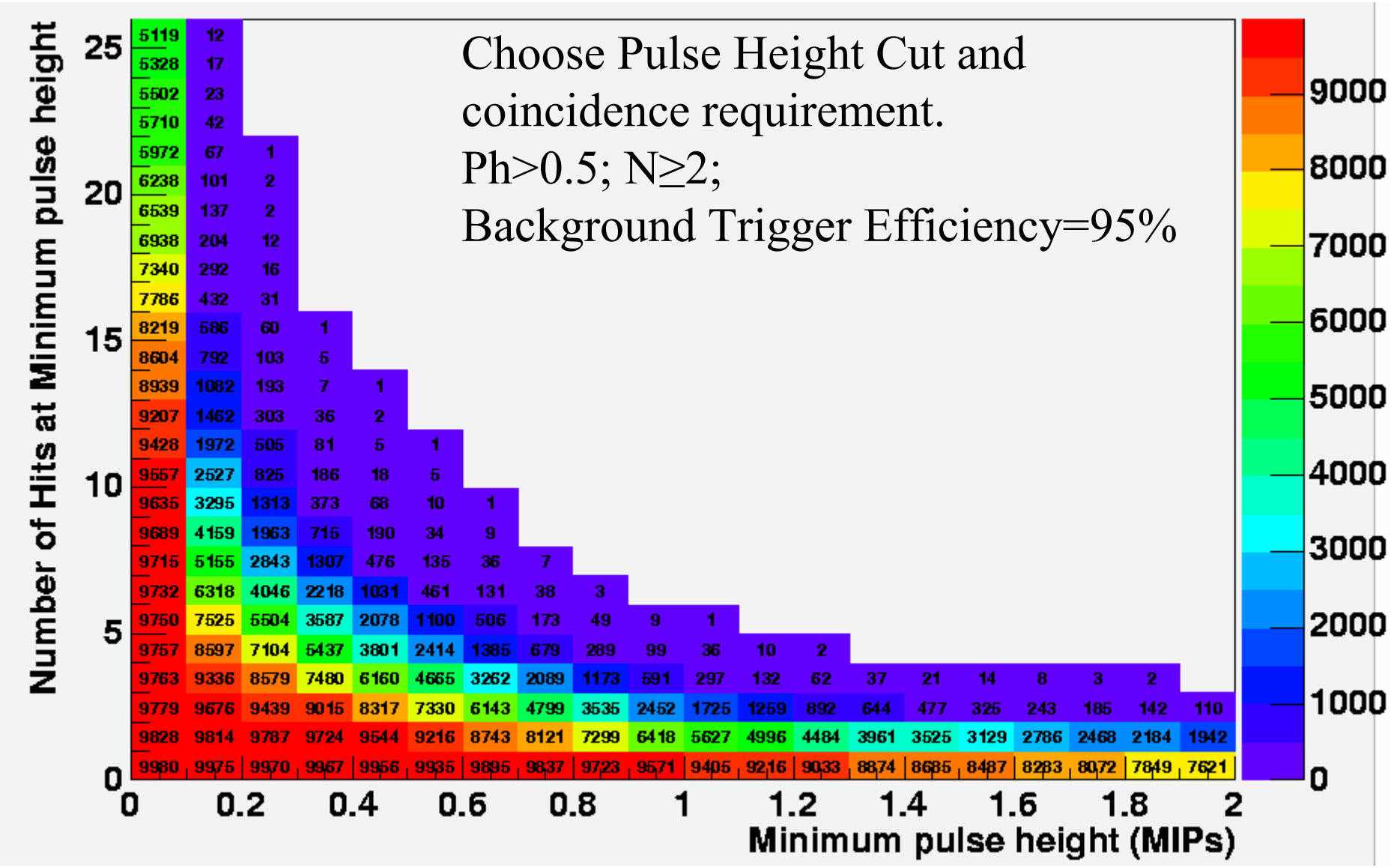
Neutron Background

- Neutron rate 30kHz E>100MeV

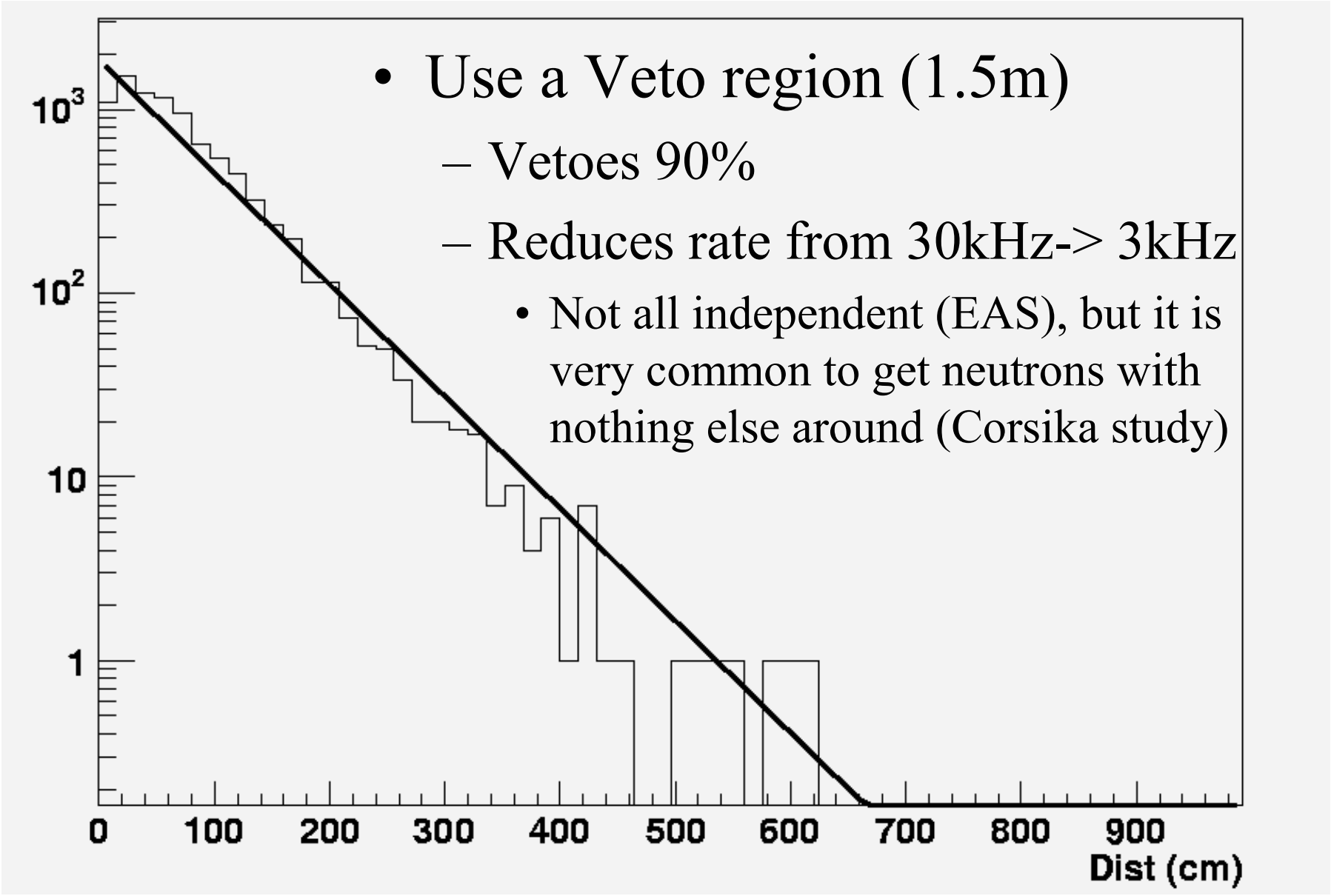
Neutron Background



Neutron Pulse Height Frequency



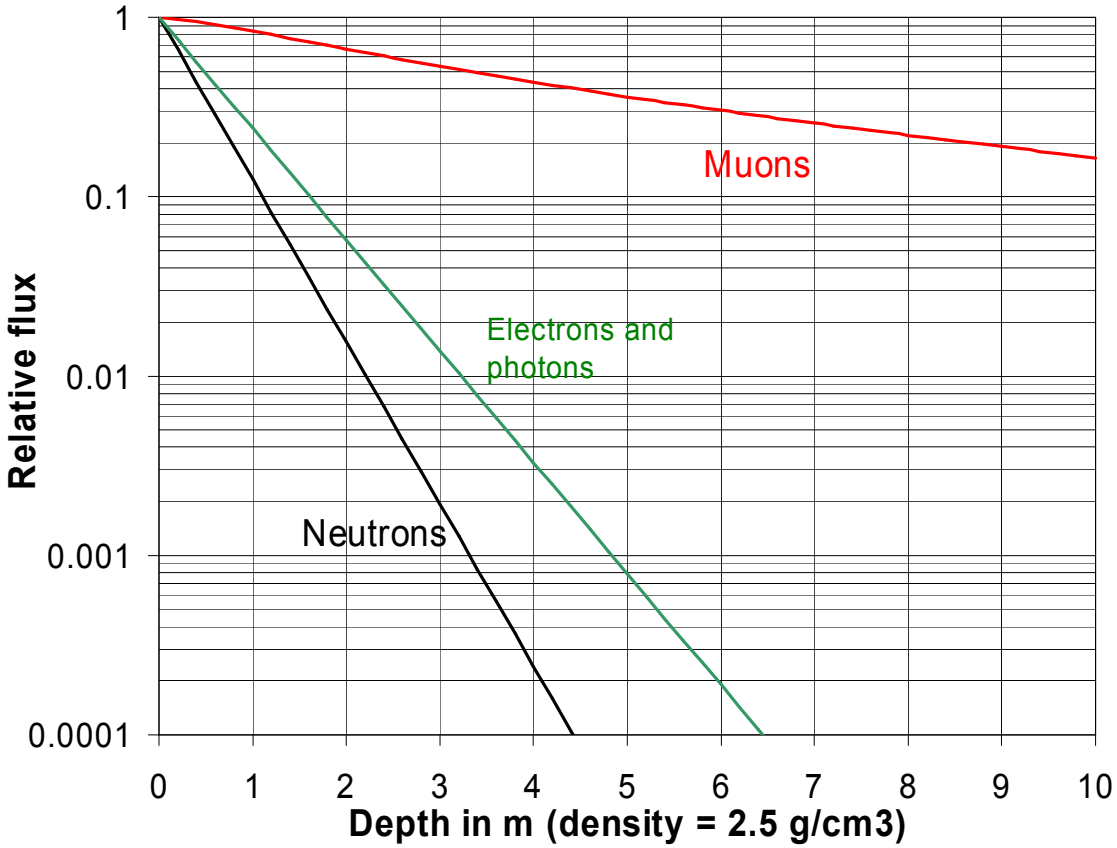
Neutron Attenuation



Effect of overburden

Assume density = 2.5 g/cm^2

- Muons:
  - 3m cuts by factor ~2
  - 5m cuts by factor ~3
- Neutrons:
  - 3m cuts by factor ~1000
  - 5m cuts by factor ~3X10^4
- EM:
  - 3m reduces ~50
  - 5m reduces ~1000



Conclusions

- Expected Signal of approximately 1500 “events” in the first second
- Requires continuous digitization and some hardware muon veto
- Backgrounds:
  - EM 20kHz –Upper limit, probably 10kHz
  - Neutron 3kHz –Upper limit
  - Natural Radioactivity ~0 (measurable?)
- FOM S/√Bkd=10 sigma minimum, probably more
- With 3m overburden background further reduced
- => 100 Hz ; FOM =>~150

10MeV Gammas